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## PROVISIONAL APPLICATION FOR PATENT COVER SHEET (Large Entity)

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INVENTOR(S)/APPLICANT(S)					
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Sharad	Mathur	602 Millrun Court Macon, GA 31210			
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TITLE OF THE INVENTION (280 characters max)					
COMPOSITIONS FOR USE IN A CHEMICAL-MECHANICAL PLANARIZATION PROCESS					
CORRESPONDENCE ADDRESS					
Direct all correspondence to: <input type="checkbox"/> Customer Number <input type="text"/> → <input type="text"/> Place Customer Number Bar Code Label here					
OR					
<input checked="" type="checkbox"/> Firm or Individual Name <b>Engelhard Corporation</b>					
Address	101 Wood Avenue				
Address					
City	Iselin	State	New Jersey	ZIP	08830
Country	USA	Telephone	(732) 205-7125	Fax	(732) 205-6727
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Respectfully submitted,

SIGNATURE

DATE March 17, 2003

TYPED or PRINTED NAME **Russell G. Lindenfelder**

REGISTRATION NO. 39,750  
(if appropriate)

TELEPHONE (732) 205-7125

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COMPOSITIONS FOR USE IN A CHEMICAL-MECHANICAL  
PLANARIZATION PROCESS

5

FIELD OF THE INVENTION

The present invention relates to a novel slurry for chemical-mechanical polishing (CMP). The present invention is applicable to manufacturing high speed integrated circuits 10 having submicron design features and high conductivity interconnect structures with high production throughput.

BACKGROUND OF THE INVENTION

In the fabrication of integrated circuits and other 15 electronic devices, multiple layers of conducting, semiconducting, and dielectric materials are deposited on or removed from a surface of a substrate. Thin layers of conducting, semiconducting, and dielectric materials may be deposited by a number of deposition techniques. Common 20 deposition techniques in modern processing include physical vapor deposition (PVD), also known as sputtering, chemical vapor deposition (CVD), plasma-enhanced chemical vapor deposition (PECVD), and now electrochemical plating (ECP).

As layers of materials are sequentially deposited and 25 removed, the uppermost surface of the substrate may become non-planar across its surface and require planarization.

Planarizing a surface, or "polishing" a surface, is a process where material is removed from the surface of the substrate to form a generally even planar surface. Planarization is useful

in removing undesired surface topography and surface defects, such as rough surfaces, agglomerated materials, crystal lattice damage, scratches, and contaminated layers or materials.

Planarization is also useful in forming features on a substrate

5 by removing excess deposited material used to fill the features and to provide an even surface for subsequent levels of metallization and processing.

Chemical mechanical planarization, or chemical mechanical polishing (CMP), is a common technique used to planarize

10 substrates. CMP utilizes a chemical composition, typically a slurry or other fluid medium, for selective removal of material from substrates. In conventional CMP techniques, a substrate carrier or polishing head is mounted on a carrier assembly and positioned in contact with a polishing pad in a CMP apparatus.

15 The carrier assembly provides a controllable pressure to the substrate urging the substrate against the polishing pad. The pad is moved relative to the substrate by an external driving force. Thus, the CMP apparatus effects polishing or rubbing movement between the surface of the substrate and the polishing

20 pad while dispersing a polishing composition, or slurry, to effect both chemical activity and mechanical activity.

Conventional slurries used for CMP processes contain abrasive particles in a reactive solution. Alternatively, the abrasive article can be a fixed abrasive article, such as a

25 fixed abrasive polishing pad, which may be used with a CMP composition or slurry that does not contain abrasive particles.

A fixed abrasive article typically comprises a backing sheet with a plurality of geometric abrasive composite elements adhered thereto.

Abrasives which are most extensively used in the semi-conductor CMP process are silica ( $\text{SiO}_2$ ), alumina ( $\text{Al}_2\text{O}_3$ ), ceria ( $\text{CeO}_2$ ), zirconia ( $\text{ZrO}_2$ ), and titania ( $\text{TiO}_2$ ), which can be produced by a fuming or a sol-gel method, as described in U.S. Pat Nos. 4,959,113; 5,354,490; and 5,516,346 and WO 97/40,030. There has recently been reported a composition or a slurry comprising mangania ( $\text{Mn}_2\text{O}_3$ ) (European Pat. No. 816,457) or a silicon nitride ( $\text{SiN}$ ) (European Pat. No. 786,504).

U.S. 6,508,952 discloses a CMP slurry containing any commercially available abrasive agent in particle form, such as  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{ZrO}_2$ ,  $\text{CeO}_2$ ,  $\text{SiC}$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{TiO}_2$ ,  $\text{Si}_3\text{N}_4$ , or a mixture thereof. These abrasive particles normally have a high purity, a high surface area, and a narrow particle size distribution, and thus are suitable for use in abrasive compositions as abrasive agents.

U.S. 4,549,374 discloses polishing semiconductor wafers with an abrasive slurry prepared by dispersing montmorillonite clay in deionized water. The pH of the slurry is adjusted by adding alkali such as NaOH and KOH.

Demands for electrical processing speed have continued to increase requiring higher and higher circuit densities and performance. It is now desirable to fabricate chips with 8 or more layers of circuit patterns! In principal the requirement

for more layers does not change the nature of polishing, but it does require more rigorous specifications from the polishing method. The width of each layer can be  $< 5 \mu\text{m}$ . Defects such as scratches and dishing must be lessened or eliminated. An issue 5 that further increases the technical demand is the move toward 300 mm wafers. The larger wafer makes it more difficult to maintain uniformity over larger length scales as compared to an 8", or 200 mm, wafer.

Besides adding layers, increased circuit density can 10 be achieved by decreasing the space between the individual pathways. Pathways cannot be too close as electrical spillover can occur across the  $\text{SiO}_2$  dielectric (the wafer oxide) effectively shorting out the connection. Recent technological advancements permitting the fabrication of very small, high 15 density circuit patterns on integrated circuits have placed higher demands on isolation structures.

#### SUMMARY OF THE INVENTION

High performance polishing is required in the fabrication 20 of integrated circuits (ICs) for computer and electronics applications. In essence, an IC is a device made up of many thin layers sequentially deposited on an inorganic oxide wafer. The layers have different compositions including oxide, metal, or dielectric materials, and each must be polished within narrow 25 tolerances and high selectivity in order to obtain a working device. Chemical Mechanical Polishing (CMP) is a means to

accomplish this task. Polishing is accomplished via the removal of surface features using a liquid chemical slurry and a rotating polymer brush. In an effective system, synergistic relationships between surface etching chemicals, surface 5 protecting chemicals, abrasives in the slurry, and polymer pad physics result in a uniform flat surface. In the present invention, particles having a non-spherical morphology are used as the abrasive in a CMP slurry.

10

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a depiction of the use of CMP to remove rider from a silicon dioxide layer.

Figure 2 is a depiction of polishing an etched semiconductive wafer.

15

Figure 3 is a depiction of polishing an etched wafer containing metal.

Figure 4 is a graph comparing the removal rate of copper using a CMP slurry containing aluminum oxide and a CMP slurry containing calcined kaolin particles as the abrasive.

20

Figure 5 is a Scanning Electron Micrograph (SEM) of the ultrafine abrasive particles prepared in Example 1 below.

DETAILED DESCRIPTION OF THE INVENTION

In general, CMP slurry compositions include abrasives for 25 mechanical action and at least one of: oxidizers, acids, bases, complexing agents, surfactants, dispersants, and other chemicals

for providing a chemical reaction such as oxidation on the surface to be polished. Certain poisons are typically avoided. Examples include metal ions with high mobilities, such as  $\text{Na}^+$ , or elements that undergo reaction with wafer materials such as

5 fluorine (although HF is sometimes used in post-CMP cleaning).

Non-limiting examples of available bases include  $\text{KOH}$ ,  $\text{NH}_4\text{OH}$ , and  $\text{R}_4\text{NOH}$ . Acids also can be added, which can be exemplified by  $\text{H}_3\text{PO}_4$ ,  $\text{CH}_3\text{COOH}$ ,  $\text{HCl}$ ,  $\text{HF}$  and so on. Available as such supplementary oxidizing agents are  $\text{H}_2\text{O}_2$ ,  $\text{KIO}_3$ ,  $\text{HNO}_3$ ,  $\text{H}_3\text{PO}_4$ ,

10  $\text{K}_2\text{Fe}(\text{CN})_6$ ,  $\text{Na}_2\text{Cr}_2\text{O}_7$ ,  $\text{KOCl}$ ,  $\text{Fe}(\text{NO}_3)_2$ ,  $\text{NH}_2\text{OH}$ , and  $\text{DMSO}$ . Divalent acids, such as oxalic acid, malonic acid, and succinic acid can be used as additives for the polishing composition of the present invention.

Additional suitable acid compounds that may be added to the

15 slurry composition include, for example, formic acid, acetic acid, propanoic acid, butanoic acid, pentanoic acid, hexanoic acid, heptanoic acid, octanoic acid, nonanoic acid, lactic acid, nitric acid, sulfuric acid, malic acid, tartaric acid, gluconic acid, citric acid, phthalic acid, pyrocatechoic acid, pyrogallol

20 carboxylic acid, gallic acid, tannic acid, and mixtures thereof.

Suitable corrosion inhibitors that may be added to the slurry composition include, for example, benzotriazole, 6-tolylytriazole, 1-(2,3-dicarboxypropyl) benzotriazole, and mixtures thereof.

25 Carboxylic acids, if added, may also impart corrosion inhibition properties to the slurry composition.

To increase the selectivity of tantalum and tantalum compounds relative to silicon dioxide, fluorine-containing compounds may be added to the slurry composition. Suitable fluorine-containing compounds include, for example, hydrogen 5 fluoride, perfluoric acid, alkali metal fluoride salt, alkaline earth metal fluoride salt, ammonium fluoride, tetramethylammonium fluoride, ammonium bifluoride, ethylenediammonium difluoride, diethylenetriammonium trifluoride, and mixtures thereof.

10 Suitable chelating agents that may be added to the slurry composition include, for example, ethylenediaminetetraacetic acid (EDTA), N-hydroxyethylenediaminetriacetic acid (NHEDTA), nitrilotriacetic acid (NTA), diethylklenetriaminepentacetic acid (DPTA), ethanoldiglycinate, and mixtures thereof. The chelating 15 agents may aid in the softening of the metallic surface or even help to protect low lying features or surfaces of particular composition. The idea of protection mechanisms may lead to significant improvements.

Suitable amines that may be added to the slurry composition 20 include, for example, hydroxylamine, monoethanolamine, diethanolamine, triethanolamine, diethyleneglycolamine, N-hydroxylethylpiperazine, and mixtures thereof.

Suitable surfactant compounds that may be added to the slurry composition include, for example, any of the numerous 25 nonionic, anionic, cationic, or amphoteric surfactants known to those skilled in the art.

The pH of the slurry is vital to the performance of all slurry components. The acidity level of a solution can control reaction rates at the surface, formation constants of metal complexing agents, rates of surface oxidation, solution ionic 5 strength, aggregation size of slurry particles, and more.

Examination of various acids, bases, and pH buffers are a prospective area for CMP development.

In accordance with the present invention, a CMP slurry is provided in which the abrasive is formed of particles having a 10 morphology wherein at least one dimension (height, length and/or width) is substantially larger than another. For purposes of this application, a such a morphology will be described as "non-spherical." Thus, a non-spherical particle morphology may be plate-like, sheet-like, needle-like, capsule-like, or any other 15 of a myriad of shapes having at least one dimension substantially larger than another. Such morphology distinguishes over spherical particles which are substantially round in appearance and do not have noticeable elongated surfaces. Laminar clays such as kaolin, mica, talc, graphite 20 flake, glass flake, and synthetic polymer flake are useful as abrasives in the CMP slurries of this invention.

It is believed that the abrasive particles having a non-spherical morphology provide an advantage over the prior art ceramic oxide materials of spherical shape. It is believed that 25 the pressure of the non-spherical abrasive on the substrate surface is distributed over an area rather than a point of

contact as the spherical particles. Accordingly, non-spherical particles provide a gentle polishing action and yet reduce micro-scratching, oxide loss, as well as reduce dishing and erosion compared to the point of contact polishing achieved by 5 the hard ceramic abrasives presently used.

In addition to having a non-spherical morphology, the abrasive particles are preferably softer than the silica or alumina abrasives typically used for CMP. Accordingly, the non-spherical abrasive particles have a Mohs hardness of about 1 to 10 6. For reference, Table 1 below sets forth the various metals and abrasive particles:

TABLE 1

Materials	Mohs	Microhardness [kg mm <sup>-2</sup> ]
Copper	2.5-3.0	80
Tantalum	6.5	230
Tungsten	7.5-8.0	350
Hydrated SiO <sub>2</sub>	4-5	400-500
SiO <sub>2</sub>	6-7	1200
Copper Oxide	3.5-4.0	-
Kaolin (calcined)	4.0-6.0	
Alumina	9.0	2000
ZrO <sub>2</sub>	6.5	-
Diamond	10.0	10000

It is believed that a non-spherical abrasive having a Mohs 15 hardness between about 1-6 is hard enough to provide the necessary mechanical action of a CMP slurry, yet defects such as

scratching, dishing, and overpolishing action can simultaneously be avoided.

In general, the non-spherical particle abrasive will comprise up to 20 by weight percent of the slurry although 5 abrasive solids contents up to 60 wt.% may be prepared. More typically, amounts of less than 15% by weight and more preferably, an abrasive content in amounts of from 0.5-8 wt.% are utilized.

At present, kaolin clay particles are preferred as the non-spherical abrasive. While hydrous kaolin can be utilized, it has been found that if the kaolin has been calcined, a better 10 polishing rate results. Calcination of the kaolin to undergo a strong endothermic reaction associated with dehydroxylation results in metakaolin. Kaolin clay calcined under conditions 15 more severe than those used to convert kaolin to metakaolin, i.e., kaolin clay calcined to undergo the characteristic kaolin exothermic reaction, results in the spinel form of calcined kaolin and also mullite if more extreme conditions are utilized. Generally, calcination of the hydrous kaolin at temperatures of 20 1200°F and higher results in the dehydroxylation of hydrous kaolin to metakaolin. Calcination temperatures of 1400-2200°F can be used to produce a kaolin clay that has been calcined through its characteristic exotherm to spinel form kaolin. At 25 the higher temperatures, e.g. above 1900°F, formation of mullite occurs. Any and all of these forms of kaolin clay can be utilized as the abrasive of this invention. All of these

materials are available commercially from the present assignee, Engelhard Corporation, Iselin, New Jersey.

Particle sizes of the non-spherical abrasive regardless of the type utilized will typically have an average diameter of 0.1 5 to 1 micron as measured by x-ray sedimentation, e.g. Sedigraph 5100. Light scattering techniques for measuring the psd would be expected to provide a different value of the average particle size. Preferably, the average particle size will range from about 0.1 to 0.5 micron. Thus, the particles which are used can 10 be characterized as nanoparticles.

The non-spherical abrasive can be combined with any of the chemical adjuvants which typically form a CMP slurry, such as acids, bases, dispersants, oxidizers, complexing agents, surfactants and/or passivating agents. The CMP slurry 15 containing the non-spherical abrasive agent can be utilized in any CMP processing. Examples of typical CMP processing are described below. These are intended to be examples only and are not provided for the purpose of limiting the uses of the CMP slurries of this invention to the specific processing techniques 20 or conditions disclosed. Thus, the CMP slurries of this invention containing the non-spherical abrasive are intended to be used for any of the CMP processes which are now known or can be utilized in the future as the complexity of the integrated circuits increases.

25 For example, in oxide-CMP, the pH of the aqueous solution is adjusted to maintain the suspension of small particles and to

soften the surface of the silicon wafer such that the high features can be ground away by the action of the abrasives. The surface of the wafer is thought to undergo a transformation under the alkaline conditions as sketched in Figure 1. As shown 5 in Figure 1, substrate 10 formed of silicon dioxide is treated by the combination of chemical (alkaline reactivity) and mechanical action (particles abrasion). This situation represents the most straight forward case of oxide-only polishing. Thus, the silicon-oxide-silicon bonds are broken by 10 the alkaline reaction and the individual silicon hydroxide moieties on the surface are removed by the mechanical abrasive action.

In order to place an electrical circuit on a chip, a pattern must be etched on the wafer surface as in Figure 2. In 15 this embodiment, substrate 12 has been etched to form a series of channels 14 which can be filled with dielectric or conductive metal components. The etched substrate 12 increases the challenge of polishing because the surface is not uniform. The substrate 12 as shown has an etched area of low pattern density 20 (A) and an area of high pattern density (B). Surface removal during polishing tends to be greater in areas (B) where the pattern density is high because the local pressure exerted by the pad is distributed over less surface area. Other defects such as erosion and rounding of sharp corners and features of 25 the pattern must also be minimized.

Once the wafer containing an etched pattern is prepared, a metal layer can be applied, which will be the electrical circuit. Figure 3 illustrates such a wafer which includes wafer substrate 16, patterned area or channels 18, and metal or metal 5 alloy 20 contained within the patterned areas. The metal used is usually a conductive copper/aluminum (Cu/Al) alloy or tungsten (W), which are more resistant to temperature and oxidation than bulk Cu metal. Polishing is required to remove the metal overburden 22 as the metal layer extends beyond the 10 low lying etched areas. Metal polishing, as opposed to oxide polishing, is accomplished using an oxidizing agent in the aqueous solution in order to form a soft oxide layer on the metal surface that can be removed by the mechanical abrasives in the slurry. Again, the use of both chemical and mechanical 15 means are used to polish the surface.

There are added challenges with metal-CMP. Multiple surface compositions are present with varied coverage densities, yet a uniform removal of metal must be attained. All the overburden metal must be removed in order to prevent electrical 20 shorts between the circuit lines. Some of the metal surface 20 may undergo metal overpolishing within the trench areas 18 called dishing as indicated by reference numeral 24 in Figure 3. An approach to limit dishing is to add a complexing agent that binds to the low lying metal areas, forming a protective layer 25 and limiting further metal erosion from slurry oxidizers.

Clearly, the aqueous slurry and pad composition must be chosen carefully to balance erosion and protection processes.

Removing excess metal or other contamination from smaller and smaller spaces between individual pathways presents ever 5 increasing challenges for CMP processing. Copper metal has a smaller intrinsic resistance and capacitance than Cu/Al alloy, which is currently used as the conducting medium. Therefore, a smaller electrical potential is required to send a signal through a copper line, reducing the tendency for electrical 10 spillover. In effect, by using Cu-only, the circuit pathways can be placed closer together.

However, the use of Cu also has disadvantages. Copper does not adhere well to oxide surfaces. Copper is also susceptible to bulk oxidation as, unlike  $WO_3$  or  $Al_2O_3$ , a  $CuO$  or  $CuO_2$  surface 15 layer still allows  $O_2$  and  $H_2O$  to penetrate into the bulk metal. Moreover, Cu atoms are mobile and can migrate into the  $SiO_2$  wafer material ultimately causing the transistors in the circuit to fail. Therefore, a thin layer of low dielectric material, typically composed of tantalum, tantalum nitride, or titanium 20 nitride, is placed between the wafer oxide and conducting Cu layers. The buffer layer promotes Cu adhesion, prevents oxidation of the bulk Cu metal, prevents Cu ion contamination of the bulk oxide, and further lowers the dielectric between the circuits (i.e. allows the circuits to be even more closely 25 spaced).

One of the uses of CMP technology is in the manufacture of shallow trench isolation (STI) structures in integrated circuits formed on semiconductor chips or wafers such as silicon. The purpose of an STI structure is to isolate discrete device 5 elements (e.g., transistors) in a given pattern layer to prevent current leakage from occurring between them.

An STI structure is usually formed by thermally growing an oxide layer on a silicon substrate and then depositing a silicon nitride layer on the thermally grown oxide layer. After 10 deposition of the silicon nitride layer, a shallow trench is formed through the silicon nitride layer and the thermally grown oxide layer and partially through the silicon substrate using, for example, any of the well-known photolithography mask and etching processes. A layer of a dielectric material such as 15 silicon dioxide is then typically deposited using a chemical vapor deposition process to completely fill the trench and cover the silicon nitride layer. Next, a CMP process is used to remove that portion of the silicon dioxide layer covering the silicon nitride layer and to planarize the entire surface of the 20 article. The silicon nitride layer is intended to function as a polishing stop that protects the underlying thermally grown oxide layer and silicon substrate from being exposed during CMP processing. In some applications, the silicon nitride layer is later removed by, for example, dipping the article in an HF acid 25 solution, leaving only the silicon dioxide filled trench to

serve as an STI structure. Additional processing is usually then performed to form polysilicon gate structures.

The use of Cu and accompanying low dielectric buffer layer demand enhanced performance from polishing techniques. The new 5 techniques are called Cu-CMP but in principle do not differ significantly from previous polishing methods. The CMP process must be able to remove the soft Cu metal overburden, yet limit Cu dishing, scratching, and removal of the low dielectric buffer layer. Simultaneously, tolerances are more rigorous because of 10 more closely spaced circuit patterns. The ability to produce layers that are thin, flat, and defect free is of paramount importance.

As is also known in the art, one method for forming interconnects in a semiconductor structure is a so-called dual 15 damascene process. A dual damascene process starts with the deposition of a dielectric layer, typically an oxide layer, disposed over circuitry formed in a single crystal body, for example silicon. The oxide layer is etched to form a trench having a pattern corresponding to a pattern of vias and wires 20 for interconnection of elements of the circuitry. Vias are openings in the oxide through which different layers of the structure are electrically interconnected, and the pattern of the wires is defined by trenches in the oxide. Then, metal is deposited to fill the openings in the oxide layer. 25 Subsequently, excess metal is removed by polishing. The process is repeated as many times as necessary to form the required

interconnections. Thus, a dual damascene structure has a trench in an upper portion of a dielectric layer and a via terminating at the bottom of the trench and passing through a lower portion of the dielectric layer. The structure has a step between the 5 bottom of the trench and a sidewall of the via at the bottom of the trench.

A review of CMP processing is provided in "Advances in Chemical-Mechanical Planarization," Rajiv K. Singh and Rajiv Bajaj, MRS Bulletin, October 2002, pages 743-747. In general, 10 while the CMP process appears quite simple, achieving a detailed understanding has been limited primarily by the large number of input variables in the polishing process. Among such variables are slurry variables such as particles and chemicals, pad variables, tool variables such as down pressure and linear 15 velocity, and substrate variables such as pattern density. The article provides a good review of the process variables and emerging applications for CMP technology and is herein incorporated by reference.

20

EXAMPLE 1

Ansilex 93° calcined kaolin slurry (50% solids) supplied by Engelhard Corporation was used as the starting material. The slurry was mixed with 4 pounds per ton of Defloc 411 (ammonium polyacrylate) supplied by Sharpe Specialty Chemicals. The 25 mixture was Netzsch milled at 1.2 gallons per minute (gpm) - 2 passes using zirconia beads. After Netzsch milling, 2 pounds per

ton of Defloc 411 was again added and the mixture then spray dried in order to keep the slurry from spoiling. The spray dried product was reslurried in a Waring Blender for 5 minutes, then deslimed on the CU5000 (centrifuge) at 40% solids for 26 minutes 5 wide open. Desliming removed the ultrafine fraction of the particulate slurry, which is of interest for the CMP application. The size distribution of the spray dried and the ultrafine product as measured by Sedigraph 5100 are set forth in Table 2. An SEM of the ultrafine product, diluted several times 10 to enhance image quality, is shown in Fig. 5. The SEM was obtained using a field emission electron microscope (Jol 6500F) at 5. kV.

TABLE 2

	Ansilex 93 slurry	Spray dried product Reslurried	Ultrafine Product
PSD (mass % finer than) (microns)			
2	92	94	100
1	79	83	99
0.5	46	58	98
0.3	16	31	85
0.2	5	17	65

EXAMPLE 2

5        The ultrafine product of Example 1 was reslurried to 4%  
solids. The slurry was passed through a Puradisc 25 GD glass  
filter (25 mm diameter and pore size of 2 microns) to remove  
oversize particles. A chemical package from a generic Copper  
CMP slurry was added to the abrasive slurry. The chemical  
10      package included an oxidizer (hydrogen peroxide), a passivator  
(benzotriazole), a complexing/etching agent (citric acid), and a  
stabilizer (TEA, TX-100). For comparison, a commercial alumina-  
based CMP slurry (Cabot Microelectronics) was used.

15      The CMP slurries were tested on 200 mm Si wafers provided  
with copper interconnects and a Ta diffusion barrier by the  
dual-damascene process. A polishing machine (Novellus IPEC 372)  
with a down pressure of 2 psi was used to apply the CMP  
slurries. Results are shown in Table 3 and Figure 4. Also, see  
Figure 3 for understanding the definitions of "Pitch" and  
20      "Pattern Density" used in Table 3.

TABLE 3

Surface Topography (overpolished area)	
Alumina Slurry	Kaolin Slurry
100 $\mu\text{m}$ Pitch	100 $\mu\text{m}$ Pitch
50% Pattern Density	50% Pattern Density
Erosion and Dishing - severe overpolishing	Erosion < 1 nm
Very low Cu/Ta selectivity	Good Cu/Ta selectivity

1. Pitch = Line width + line space
2. Pattern Density = Line width/Pitch

5 The measurements in Table 3 are from the over polished area of the wafer. In case of the alumina slurry, severe overpolishing precluded measurements on dishing and erosion.

What is claimed is:

1. A chemical-mechanical abrasive slurry comprising abrasive particles having a non-spherical morphology.

5

2. The slurry claim 1 wherein said abrasive particles having a non-spherical morphology are selected from mica, talc, laminar clays, graphite flake, glass flake, and synthetic polymer flake.

10

3. The slurry of claim 2 wherein said abrasive particles comprise kaolin clay.

4. The slurry of claim 3 wherein said kaolin clay particles have 15 been calcined at a temperature of at least 1200° F.

5. The slurry of claim 1 wherein said slurry comprises up to 20 weight % of said abrasive particles.

20 6. The slurry of claim 5 wherein said slurry comprises less than 15% by weight of said abrasive particles.

7. The slurry of claim 6 wherein said slurry comprises about 0.5- 8 weight % of said abrasive particles.

25

8. The slurry of claim 1 wherein said abrasive particles have an average diameter of 0.1 - 1 micron.

9. The slurry of claim 8 wherein said abrasive particles have an average diameter of about 0.1-0.5 micron.

5 10. The slurry of claim 1 wherein said slurry comprises an oxidizer.

11. The slurry of claim 10 wherein said slurry further includes a dispersant, a passivator, a complexing agent, and at least 10 one surfactant.

12. The slurry of claim 1, wherein said abrasive particles have a Mohs hardness within the range of about 1 to 6.

15 13. A method of planarizing a semiconductor with a chemical-mechanical abrasive slurry, said semiconductor comprising a surface of semiconductive material, metal, dielectric material or mixtures thereof, said method comprising contacting said surface with said chemical-mechanical abrasive slurry, said 20 chemical-mechanical abrasive slurry comprising a particle abrasive having a non-spherical morphology.

14. The method of claim 13 wherein said particle abrasive is selected from mica, talc, laminar clays, graphite flake, glass 25 flake, and synthetic polymer flake.

15. The method of claim 14 wherein said particle abrasive is kaolin clay.
16. The method of claim 15 wherein said kaolin clay has been  
5 calcined at a temperature of at least 1200°F.
17. The method of claim 13 wherein said slurry contains up to 20% by weight of said particle abrasive.
- 10 18. The method of claim 17 wherein said slurry comprises less than 15% by weight of said particle abrasive.
- 15 19. The method of claim 18 wherein said slurry comprises from about 0.5-8 weight % of said particle abrasive.
20. The method of claim 13 wherein said particle abrasive has an average diameter of from 0.1-1 micron.
21. The method of claim 20 wherein said particle abrasive has  
20 an average size of from about 0.1-0.5 micron.
22. The method of claim 13 wherein said surface is a flat semiconductive surface.
- 25 23. The method of claim 13 wherein said surface comprises an etched semiconductive surface.

24. The method of claim 13 wherein said surface comprises a metal.

5 25. The method of claim 24 wherein said metal is copper.

26. The method of claim 13 wherein said semiconductor comprises a semiconductive substrate, a dielectric layer and a metal layer.

10

27. The method of claim 13 wherein said particle abrasive has a Mohs hardness within the range of about 1 to 6.

ABSTRACT OF THE DISCLOSURE

A chemical-mechanical abrasive composition for use in semiconductor processing uses abrasive particles having a non-spherical morphology.



Fig. 1

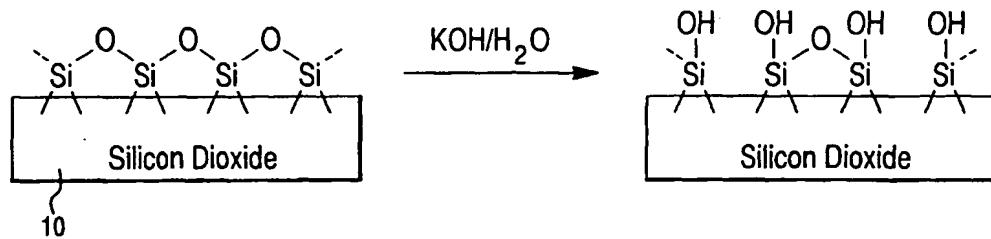


Fig. 2

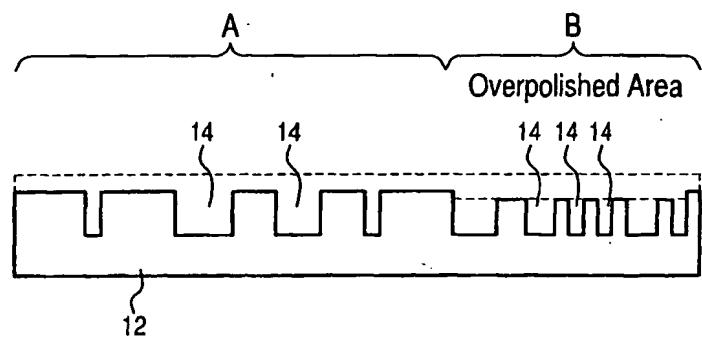


Fig. 3

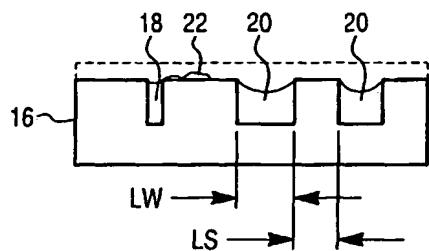
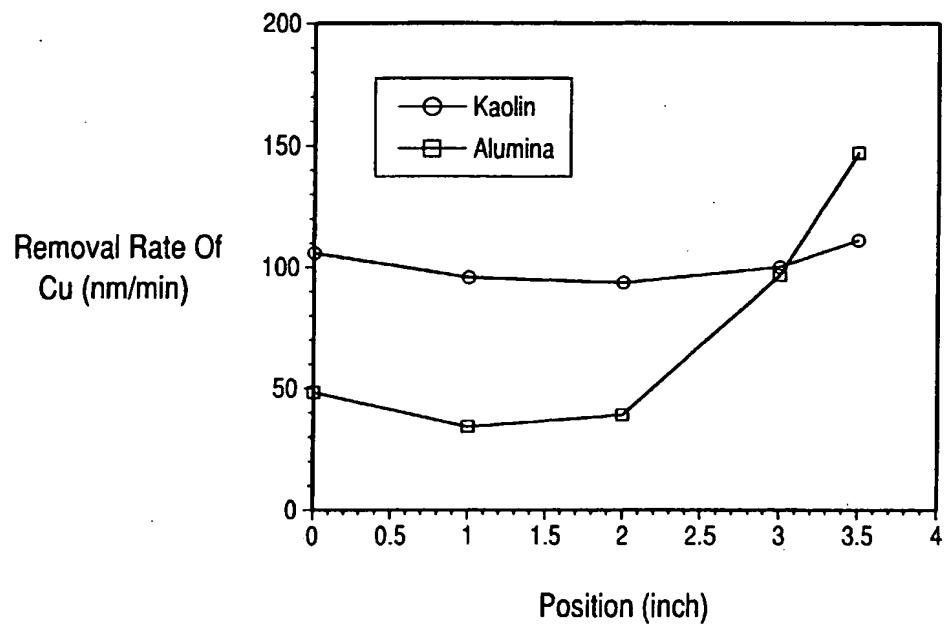
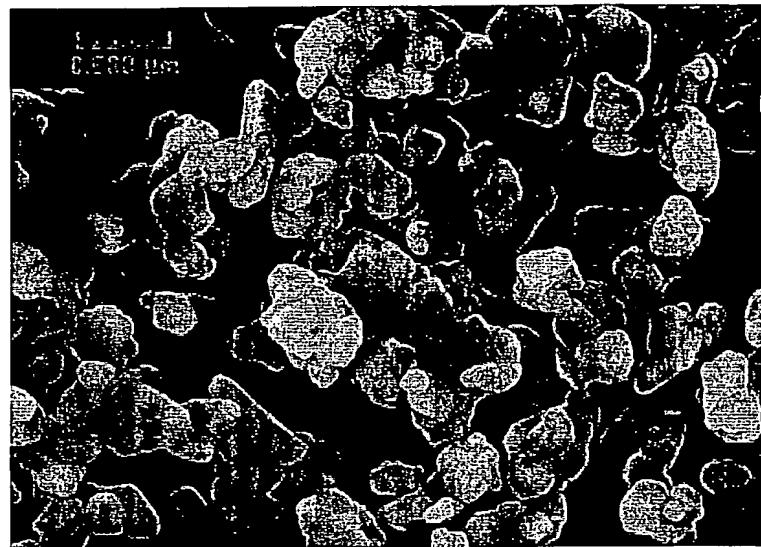


Fig. 4



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**Fig. 5**

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